STRENGTH AND C[illegible] L REINFORCED WITH BOTTOM ASH COLUMNS

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ABSTRACT

Stone column could be used as a ground improvement technique where a portion of the soft soil is replaced with granular material such as crushed rocks or sand which is proven to increase bearing capacity and accelerate the dissipation of excess pore water pressure. This research was aimed to investigate the role of bottom ash columns in improving the shear strength and compressibility of soft reconstituted kaolin clay. This was done by determining the effects of area replacement ratio, height penetrating ratio and volume replacement ratio of a single and a group of bottom ash columns on the strength characteristics and also the effects of confining pressure on the compressibility characteristics of kaolin clay reinforced with bottom ash column(s). Among the objectives of this research include establishing a design chart that correlating the undrained shear strength of bottom ash column(s) reinforced kaolin clay with the volume replacement ratio and the mean normal effective stress, through critical state soil mechanics framework. The reinforced kaolin samples were subjected to using Unconfined Compression Test (UCT) and Consolidated Undrained (CU) Triaxial Test. Research variables include diameter and height of the bottom ash columns and effective confining pressure, σ'_3 (also equals to mean normal effective stress, p'_o). Analysis of the results had been carried out using the Mohr-Coulomb and critical state failure criteria. Based the results of UCT, it can be concluded that the undrained shear strength generally increased with the increased in the height penetrating ratio but decreased after reaching an optimum improvement at 80 % of height penetrating ratio. The increment of undrained shear strength was also dependent on the area replacement ratio. Without confining pressure, the higher the area replacement ratio, the higher the strength occurred. However, excessive area of replacement decreased the shear strength of the sample reinforced by group columns since the remaining width of the soil sample was too thin to hold the columns. Based on the Mohr-Coulomb failure criteria of the CU test results, the installation of bottom ash columns did not show any significant difference in the effective friction angle. However, it did result in an increase in the apparent cohesion and undrained shear strength of the kaolin clay. It is also proven that the dissipation of pore water pressure was accelerated with the presence of bottom ash columns. Analysis through the critical state soil mechanics framework revealed critical state parameters of M, Γ and λ for each samples. Most of the M values for the soil-bottom ash composite lie between 1.25 and 1.33, giving a variation on the friction angle at critical state between 31° to 33°, hence fall under the "mixtures of gravel and sand with fine-grained soils" category. Generally it can be concluded that the shear strength and compressibility of soft clay could be improved by the installation of bottom ash columns. Hence, a design chart was established intended to become a design tool, particularly in the determining the volume of bottom ash needed to form the vertical columns achieve to the required shear strength of the improved clay soil.

ABSTRAK

Tiang batu boleh digunakan sebagai teknik pembaikan tanah yang mana sebahagian tanah lembut digantikan dengan bahan berbijian seperti batuan hancur atau pasir yang terbukti boleh meningkatkan keupayaan galas dan mempercepatkan pelesapan lebihan tekanan air liang. Penyelidikan ini bertujuan untuk mengkaji peranan tiang abu dasar dalam memperbaiki kekuatan ricih dan kebolehmampatan tanah liat kaolin lembut yang disusun semula. Ini dilakukan dengan menentukan kesan nisbah penggantian luas, nisbah ketinggian tertusuk dan nisbah penggantian isipadu bagi tiang abu dasar tunggal dan kumpulan selain kesan tekanan mengurung ke atas ciri-ciri kebolehmampatan tanah liat kaolin yang diperkukuh dengan tiang abu dasar. Antara objektif penyelidikan ini termasuk menwujudkan carta rekabentuk yang menghubungkan kekuatan ricih tak tersalir tanah liat kaolin yang diperkukuh dengan tiang abu dasar dengan nisbah penggantian isipadu dan purata tegasan normal berkesan, melalui kerangka kerja mekanik tanah keadaan genting. Sampel kaolin yang terkukuh dengan tiang abu dasar telah diuji menggunakan kaedah Ujikaji Mampatan Tak Terkurung (UCT) dan Ujikaji Tiga Paksi Terkukuh Tak Tersalir (CU). Pembolehubah kajian termasuk garis pusat dan ketinggian tiang abu dasar dan tekanan mengurung berkesan, σ'_3 (yang juga bersamaan dengan purata tegasan berkesan normal, p'_o). Keputusan telah dilakukan menggunakan kriteria-kriteria kegagalan Mohr-Coulomb dan keadaan genting. Berdasarkan keputusan UCT, boleh disimpulkan bahawa secara amnya kekuatan ricih tak tersalir meningkat dengan pertambahan nisbah tusukan ketinggian berkurang selepas mencapai pembaikan optimum pada 80 % nisbah tusukan ketinggian. Penambahan kekuatan ricih tak tersalir juga bergantung kepada nisbah penggantian luas. Tanpa tekanan mengurung, semakin tinggi nisbah penggantian luas, semakin tinggi kekuatan yang berlaku. Walau bagaimanapun, penggantian luas berlebihan menyebabkan kekuatan ricih tanah berkurangan bagi sampel tanah yang diperkukuhkan dengan tiang berkumpulan disebabkan lebar sampel tanah yang tinggal akan menjadi terlalu nipis untuk memegang tiang. Melalui kriteria kegagalan Mohr-Coulomb menggunakan keputusan ujikaji CU, pemasangan tiang abu dasar tidak menunjukkan perubahan besar dalam sudut geseran berkesan. Namun, ia menunjukkan peningkatan dalam lekatan nyata dan kekuatan ricih tak tersalir bagi tanah liat kaolin. Ianya juga terbukti bahawa pelesapan lebihan tekanan air liang dipercepatkan dengan kehadiran tiang abu dasar. Analisis melalui kerangka kerja mekanik tanah keadaan kritikal memperkenalkan parameter keadaan kritikal M, Γ dan λ untuk setiap sampel. Kebanyakan nilai M bagi komposit tanah-abu dasar adalah di antara 1.25 dan 1.33, memberikan variasi sudut geseran pada keadaan kritikal di antara 31° hingga 33°, menjadikannya termasuk di dalam kategori "campuran kerikil dan pasir dengan tanah butiran halus". Umumnya, kuatan ricih dan kebolehmampatan bagi tanah liat boleh bertambah baik oleh pemasangan tiang abu dasar. Satu carta rekabentuk telah dihasilkan bertujuan untuk menjadi panduan untuk proses rekabentuk, terutamanya dalam menentukan isipadu abu dasar yang diperlukan untuk menghasilkan tiang tegak, bagi mencapai kekuatan ricih yang diperlukan untuk menambah baik tanah liat.

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AASHTO	-	American Association of State Highway and Transportation Officials
ASTM	-	American Society for Testing and Materials
BA	-	Bottom Ash
BS	-	British Standard
C	-	Controlled Sample
CBR	-	California Bearing Ratio
CSL	-	Critical State Line
CD	-	Consolidated Drained
CU	-	Consolidated Undrained
G	-	Group Columns
LL	-	Liquid Limit
NCL	-	Normal Consolidation Line
PI	-	Plasticity Index
PL	-	Plastic Limit
SL	-	Shrinkage Limit
S	-	Single Column
SEM	-	Scanning Electron Microscope
UCT	-	Unconfined Compression Test
US	-	United States
USCS	-	Unified Soil Classification System